Groundwater Pathway

Results in Brief: 2000 Groundwater Pathway

Enhanced Groundwater Remedy - During 2000 active restoration of the Great Miami Aquifer continued at the following four groundwater restoration modules:

- South Plume Module, which became operational on August 27, 1993
- South Field (Phase I) Extraction Module, which became operational on July 13, 1998
- South Plume Optimization Module, which became operational on August 9, 1998
- Re-Injection Module, which became operational on September 2, 1998.

Since 1993

- 7,516 million gallons (28,448 million liters) of water have been pumped from the Great Miami Aquifer.
- 859 million gallons (3,251 million liters) of water have been re-injected into the Great Miami Aquifer.
- 2,356 pounds (1,070 kg) of total uranium have been removed from the Great Miami Aquifer.

During 2000

- 1,879 million gallons (7,112 million liters) of water were pumped from the Great Miami Aquifer.
- 299 million gallons (1,132 million liters) of water were re-injected into the Great Miami Aquifer.
- 845 pounds (384 kg) of total uranium were removed from the Great Miami Aquifer.

Pumping of two new South Field extraction wells (32446 and 32447) began in February 2000. The wells were installed in response to a newly defined area of uranium contamination.

Director's Findings and Orders were issued by OEPA on September 7, 2000. These orders specify that the site's groundwater monitoring activities will be implemented in accordance with the IEMP. The revised language allows modification of the groundwater monitoring program as necessary, via the IEMP revision process, without issuance of a new order.

Groundwater re-injection was adopted as part of the groundwater remedy at the FEMP.

The designs for aquifer restoration modules in the waste storage and Plant 6 areas were revised significantly based on groundwater characterization efforts completed in 1999 and 2000.

Groundwater Monitoring Results - Geoprobe® sampling data, along with routine IEMP monitoring well data in the South Field area continue to indicate that surface source removal, flushing of the contaminants toward the extraction wells by infiltrating surface water, and pumping the extraction wells are all contributing to reducing the total uranium concentration in the western portion of this plume, particularly beneath the former Inactive Flyash Pile. However, some monitoring wells in the eastern portion of the South Field Module area have steady or increasing total uranium concentrations. Options for increasing the flushing of the aquifer in the eastern portion of the South Field area are scheduled to be evaluated in 2001.

On-Site Disposal Facility Monitoring - Leak detection monitoring during 2000 indicated that the liner systems for Cells 1, 2, and 3 are performing within the specifications outlined in the approved on-site disposal facility design documents.

This chapter provides background information on the nature and extent of groundwater contamination in the Great Miami Aquifer due to past operations at the FEMP and summarizes:

- Significant achievements realized by the Operable Unit 5 Aquifer Restoration and Wastewater Project in 2000
- Groundwater monitoring activities and results for 2000.

Restoration of the affected portions of the Great Miami Aquifer and continued protection of the groundwater pathway are primary considerations in the accelerated remediation strategy for the FEMP. The FEMP will continue to monitor the groundwater pathway throughout remediation to ensure the protection of this primary exposure pathway.

Groundwater Modeling at the FEMP

The FEMP uses computer models to make predictions about how the contaminants in the aquifer will look in the future. Because the model contains simplifying assumptions about the aquifer and the contaminants, the predictions about future behavior must be verified with field measurements obtained from groundwater monitoring activities.

If groundwater monitoring data indicate the need for operational changes to the groundwater remedy, then the groundwater model is run to predict the effect those changes might have on the aquifer and the contaminants. If the predictions indicate the proposed changes would increase clean-up efficiency and reduce the clean-up time and cost, then the operational changes are made and monitoring data are collected after the changes to verify whether model predictions were correct. If model predictions prove to be incorrect, then modifications are made to the model to improve its predictive capabilities.

Summary of the Nature and Extent of Groundwater Contamination

The nature and extent of groundwater contamination from operations at the FEMP has been investigated, and the risk to human health and the environment from those contaminants has been evaluated in the Operable Unit 5 Remedial Investigation Report (DOE 1995d). As documented in that report, the primary groundwater contaminant at the FEMP is uranium. Approximately 230 acres (93 hectares) of the Great Miami Aquifer are contaminated above the 20 µg/L groundwater FRL for total uranium.

Contamination of the groundwater resulted from infiltration through the bed of Paddys Run, the Storm Sewer Outfall Ditch, and the Pilot Plant Drainage Ditch. In these areas, the glacial overburden is eroded, and the sand and gravel of the aquifer are in direct contact with uranium-contaminated surface water from the FEMP. To a lesser degree, groundwater contamination also resulted where past excavations, such as the waste pits, removed some of the protective clay contained in the glacial overburden and exposed the aquifer to contamination.

Selection and Design of the Groundwater Remedy

After the nature and extent of groundwater contamination was defined, various remediation technologies were evaluated in the Feasibility Study Report for Operable Unit 5 (DOE 1995). Remediation cost, efficiency, and various land-use scenarios were considered during the development of the preferred remedy for restoring the quality of the groundwater in the aquifer.

The Operable Unit 5 Feasibility Study Report recommended a pump-and-treat remedy for the groundwater contaminated with uranium. The remedy consisted of 28 groundwater extraction wells located on and off property. Computer modeling suggested that the 28 extraction wells pumping at a combined rate of 4,000 gpm (15,000 L/min) would remediate the aquifer within 27 years. The recommended groundwater remedy was presented to EPA, OEPA, and FEMP stakeholders in the Proposed Plan for Operable Unit 5 (DOE 1995c).

Once the preferred groundwater remedy was identified and approved in the Operable Unit 5 Proposed Plan, the Operable Unit 5 Record of Decision was presented to FEMP stakeholders and subsequently approved by EPA and OEPA in January 1996. The Operable Unit 5 Record of Decision formally defined the selected groundwater remedy and established FRLs for all constituents of concern. The Operable Unit 5 Record of Decision committed to ongoing evaluation of innovative remediation technologies so that remedy performance could be improved as such technologies become available. As a result of this commitment, an enhanced groundwater remedy was presented in the Operable Unit 5 Baseline Remedial Strategy Report, Remedial Design for Aquifer Restoration (Task 1) (DOE 1997a).

The enhanced groundwater remediation strategy, which relies on pump-and-treat and re-injection technology is being used to conduct a concentration-based clean up of the Great Miami Aquifer. The restoration strategy focuses primarily on the removal of uranium, but also has been designed to limit the further expansion of the plume, achieve removal of all targeted contaminants to concentrations below designated FRLs, and prevent undesirable groundwater drawdown impacts beyond the FEMP property.

Re-Injection at the FEMP

Re-injection is an enhancement to the groundwater remedy. Groundwater pumped from the aquifer is treated to remove contaminants and then re-injected back into the aquifer at strategic locations. The re-injected groundwater increases the speed at which contaminants move through the aquifer and are pulled by extraction wells, thereby decreasing the overall remediation time.

A groundwater re-injection demonstration was conducted at the FEMP from September 2, 1998, to September 2, 1999. Following completion of the re-injection demonstration in September of 1999, the Re-Injection Demonstration Test Report (DOE 2000c) was issued to EPA and OEPA in May 2000. This report details the demonstration and recommends its incorporation into the FEMP's aquifer restoration strategy. Based on the results of the demonstration, re-injection will continue at the FEMP. Accordingly, the Re-Injection Demonstration Module has been renamed the Re-Injection Module to reflect completion of the demonstration. The Re-Injection Module Operational Summary section within this chapter provides more discussion of this topic.

The enhanced groundwater remedy also included additional extraction wells in on-site areas of aquifer contamination. Groundwater modeling studies conducted in support of the enhanced groundwater remedy suggest that, with the early installation of additional extraction wells and re-injection technology, the remedy could potentially be reduced to 10 years. EPA and OEPA approved the enhanced groundwater remedy.

While the remedial investigation and feasibility study process was in progress and a groundwater remedy was being selected, off-property contaminated groundwater was being pumped from the South Plume area by the South Plume Removal Action System (referred to as the South Plume Module). In 1993 this system was installed south of Willey Road and east of Paddys Run Road to stop the total uranium plume in this area from migrating any further to the south. Figure 3-1 shows the South Plume Module Extraction Wells 3924, 3925, 3926, and 3927. These extraction wells have successfully stopped further southern migration of the total uranium plume beyond the wells and have contributed to significantly reducing total uranium concentrations in the off-property portion of the plume.

During 1998 significant portions of the enhanced groundwater remedy infrastructure were completed. By the end of June 1998, construction was complete on the pipeline distribution network and associated electronic controls for three groundwater restoration modules: South Plume Optimization Module, South Field (Phase I) Extraction Module, and Re-Injection Demonstration Module. By September 1998, all three modules were on line and, in combination with the South Plume Module, were pumping 3,500 gpm (13,000 L/min) from the aquifer and re-injecting 1,000 gpm (3,800 L/min).

During 2000 active remediation of the Great Miami Aquifer continued at the following groundwater restoration modules: South Plume/South Plume Optimization Module, South Field (Phase I) Extraction Module, and Re-injection Module. As identified in the 1999 Integrated Site Environmental Report (DOE 2000b), Extraction Wells 32446 and 32447 were installed during the fourth quarter of 1999 to supplement the South Field (Phase I) Extraction Module. The location of these wells was based on refined total uranium plume interpretations and groundwater modeling. These two wells began pumping in February 2000. Figure 3-1 depicts the current extraction and re-injection well locations. The operational information associated with these modules is presented in subsequent subsections.

As a result of a conceptual design groundwater characterization program conducted in the waste storage and Plant 6 areas in late 1999 and early 2000, a total uranium plume in the Plant 6 area exceeding 20 µg/L was not detected. It is believed that the plume has dissipated to concentrations that are below 20 µg/L as a result of the shutdown of plant operations in the late 1980s and the pumping of highly contaminated perched water as part of the Perched Water Removal Action in the early 1990s. Because a total uranium plume with concentrations above 20 µg/L is no longer present in the Plant 6 area, a restoration module for this area is no longer planned. However, groundwater monitoring will continue in the Plant 6 area until the groundwater in this area is certified as clean. The conceptual design groundwater characterization also indicated the total uranium plume in the waste storage area is smaller than what was estimated during the remedial investigation/feasibility study (approximately 55 acres [22 hectares] versus 70 acres [28 hectares]). However, a portion of the waste storage area total uranium plume in the vicinity of the confluence of Paddys Run and the Pilot Plant Drainage Ditch has been re-defined as extending farther to the east than previously estimated. In addition, total uranium concentrations up to 566 µg/L have been found in this area.

Figure 3-2 identifies current and future extraction and re-injection well locations based on the 1997 Baseline Remedial Strategy Report. The actual location of future extraction wells will be based on the most up-to-date characterization and modeling efforts. The actual locations of the initial wells in the waste storage area will be defined as part of the detailed design of the Waste Storage Area Module to be completed in 2001.

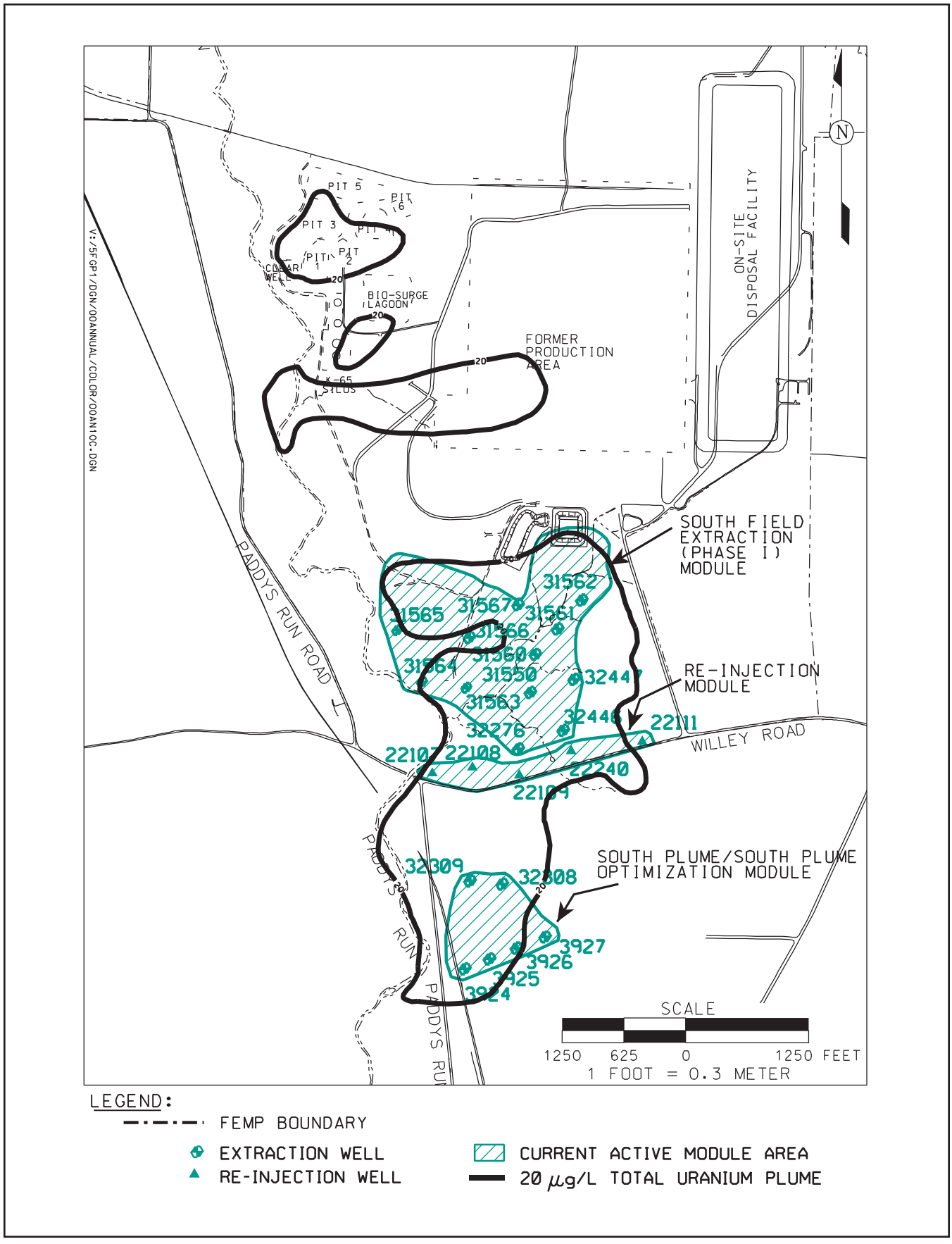


Figure 3-1. Current Extraction and Re-Injection Wells

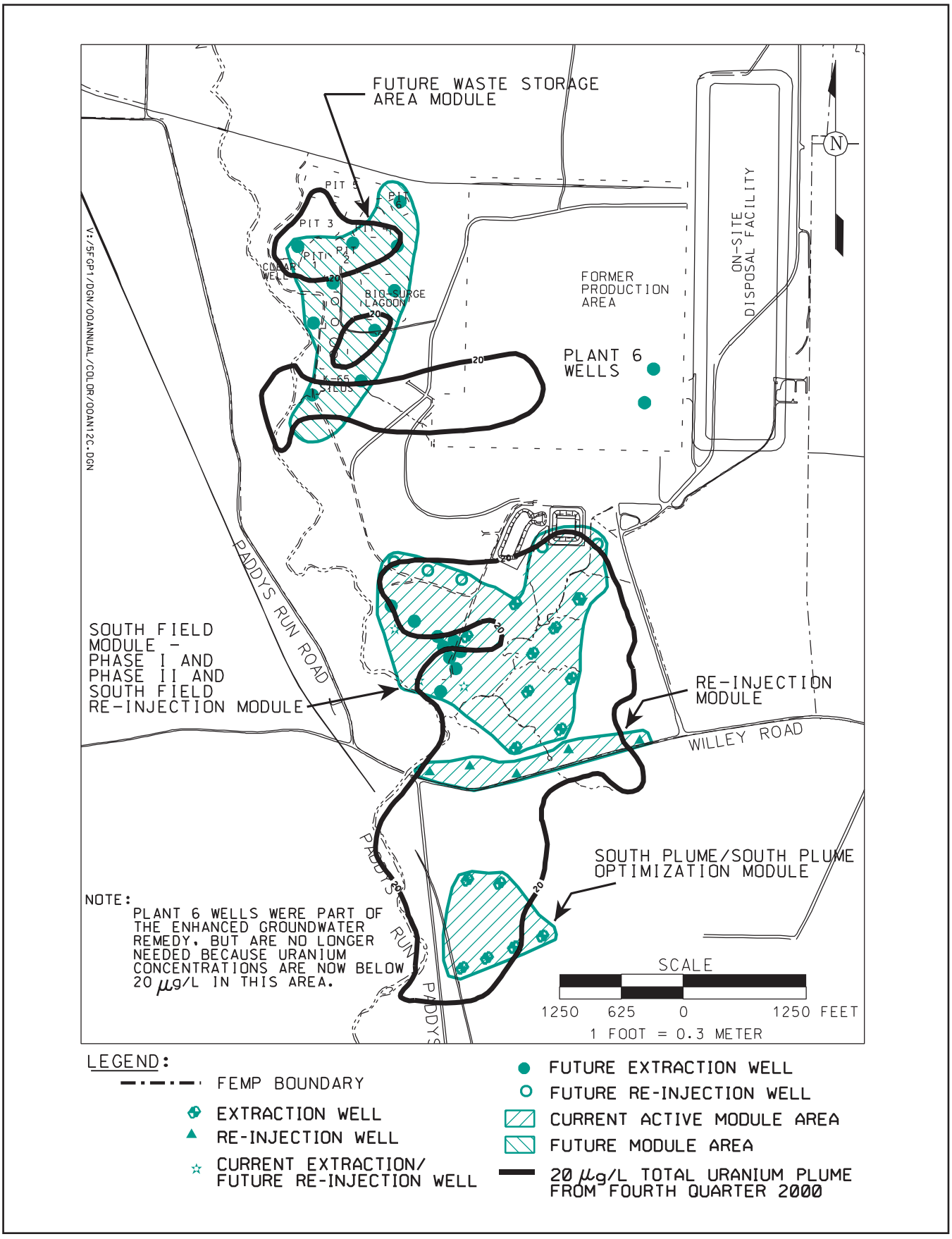


Figure 3-2. Current and Future Extraction and Re-Injection Wells for the Enhanced Groundwater Remedy

Groundwater Monitoring Highlights for 2000

For this report, groundwater monitoring results are discussed in terms of restoration and compliance monitoring.

The key elements of the FEMP groundwater monitoring program design are described below:

- **Sampling** - Sample locations, frequency, and the constituents were selected to address operational assessment, restoration assessment, and compliance requirements. Selected wells are monitored for up to 50 groundwater FRL constituents as identified in Table 2-2. Monitoring is conducted to ascertain groundwater quality and groundwater flow direction. Figure 3-3 shows a typical groundwater monitoring well at the FEMP and Figure 3-4 identifies the relative placement depths of groundwater monitoring wells at the FEMP. As part of the comprehensive IEMP groundwater-monitoring program, approximately 140 wells were monitored for water quality in 2000. Figure 3-5 identifies the location of the current IEMP water quality monitoring wells, including extraction wells. In addition to water quality monitoring, approximately 184 wells were monitored quarterly for groundwater elevations. Figure 3-6 depicts the IEMP routine water-level (groundwater elevation) monitoring wells, including extraction wells.

- **Data Evaluation** - The integrated data evaluation process looks at the data collected from wells to determine: capture and restoration of the total uranium plume, capture and restoration of non-uranium FRL constituents, water quality conditions in the aquifer that indicate a need to modify the design and installation of restoration modules, and the impact of on-going groundwater restoration on the Paddys Run Road Site plume (a separate contaminant plume south of the FEMP property along Paddys Run Road resulting from independent industrial activities in the area).

- **Reporting** - Groundwater reporting requirements are combined into IEMP quarterly reports and annual integrated site environmental reports.

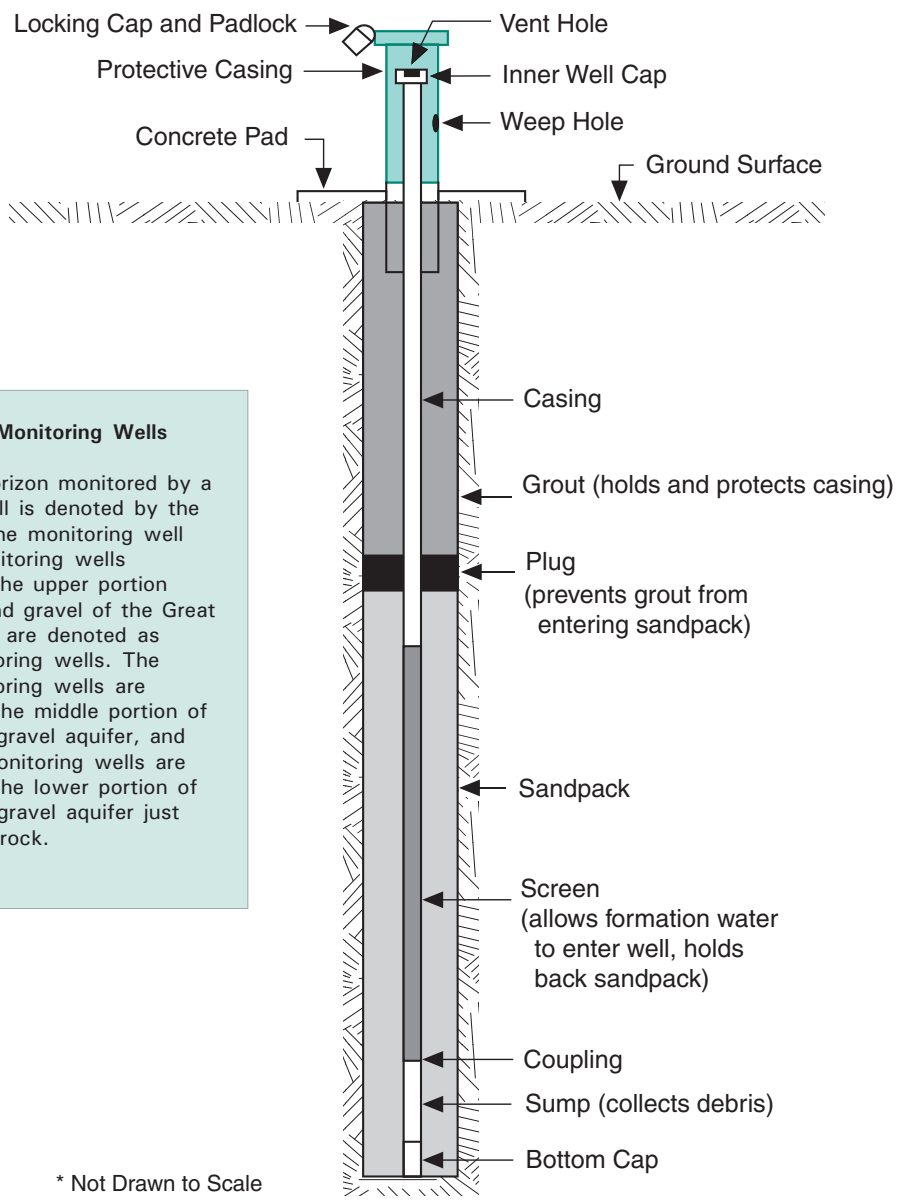
Restoration Monitoring

In general, restoration monitoring tracks the progress of the groundwater remedy and water quality conditions. Restoration monitoring is discussed in the following subsections:

- Operational Summary
  - South Plume/South Plume Optimization Module
  - South Field (Phase I) Extraction Module
  - Re-Injection Module
- Monitoring Results for Total Uranium
- Monitoring Results for Non-Uranium Constituents.

All operational modules are evaluated quarterly. The evaluation is done by collecting and mapping groundwater quality and groundwater elevation data and then analyzing the results. Concentration maps are developed from analytical data and compared with groundwater elevation maps depicting the location of the capture zone.

More detailed information on the above can be found in Appendix A of this report. Each subsection below identifies the specific Attachment of Appendix A where the detailed information can be found.



Groundwater Monitoring Wells

The aquifer horizon monitored by a monitoring well is denoted by the first digit of the monitoring well number. Monitoring wells completed in the upper portion of the sand and gravel of the Great Miami Aquifer are denoted as Type 2 monitoring wells. The Type 3 monitoring wells are completed in the middle portion of the sand and gravel aquifer, and the Type 4 monitoring wells are completed in the lower portion of the sand and gravel aquifer just above the bedrock.

Figure 3-3. Monitoring Well Diagram

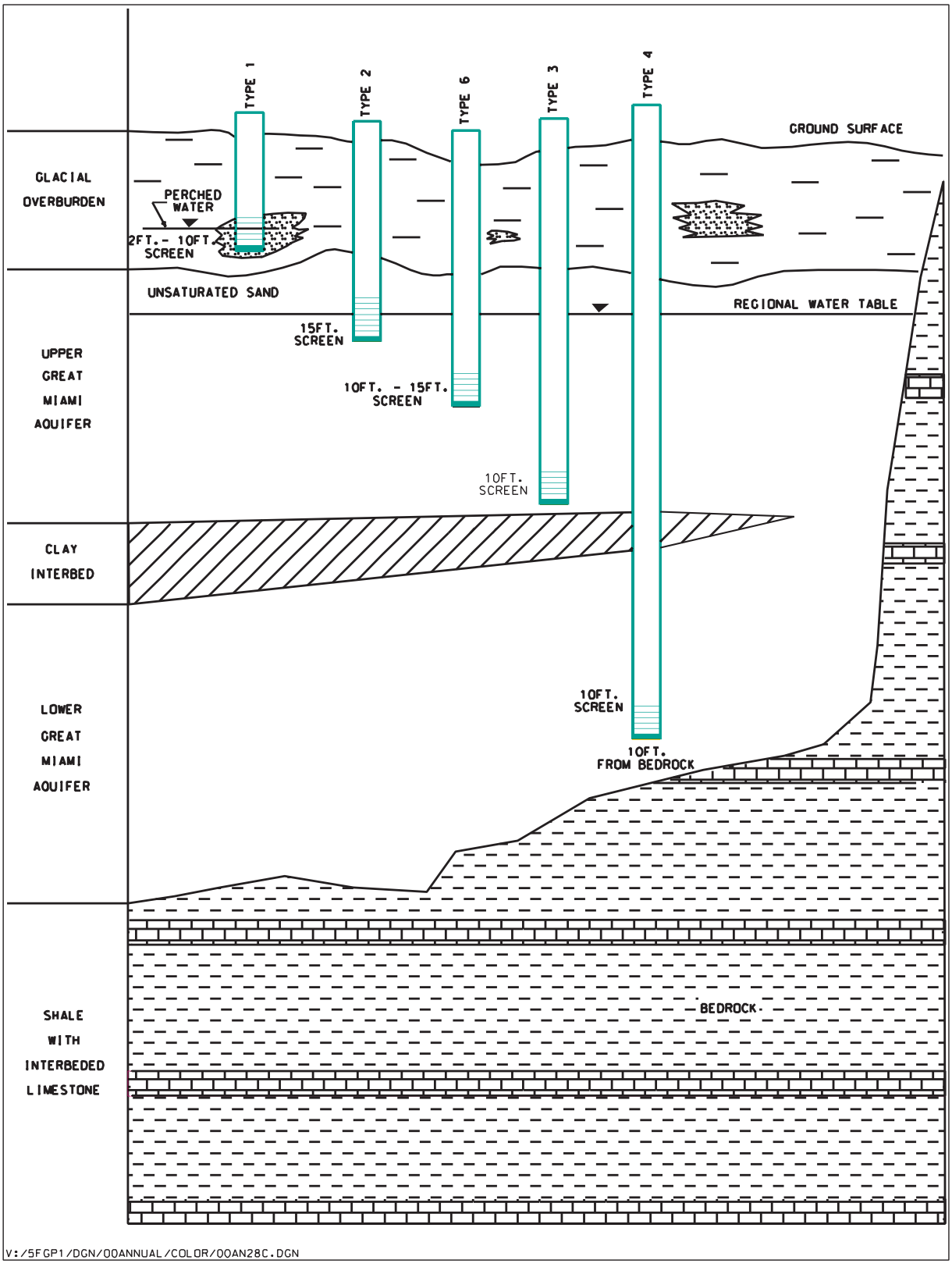


Figure 3-4. Monitoring Well Relative Depths and Screen Locations

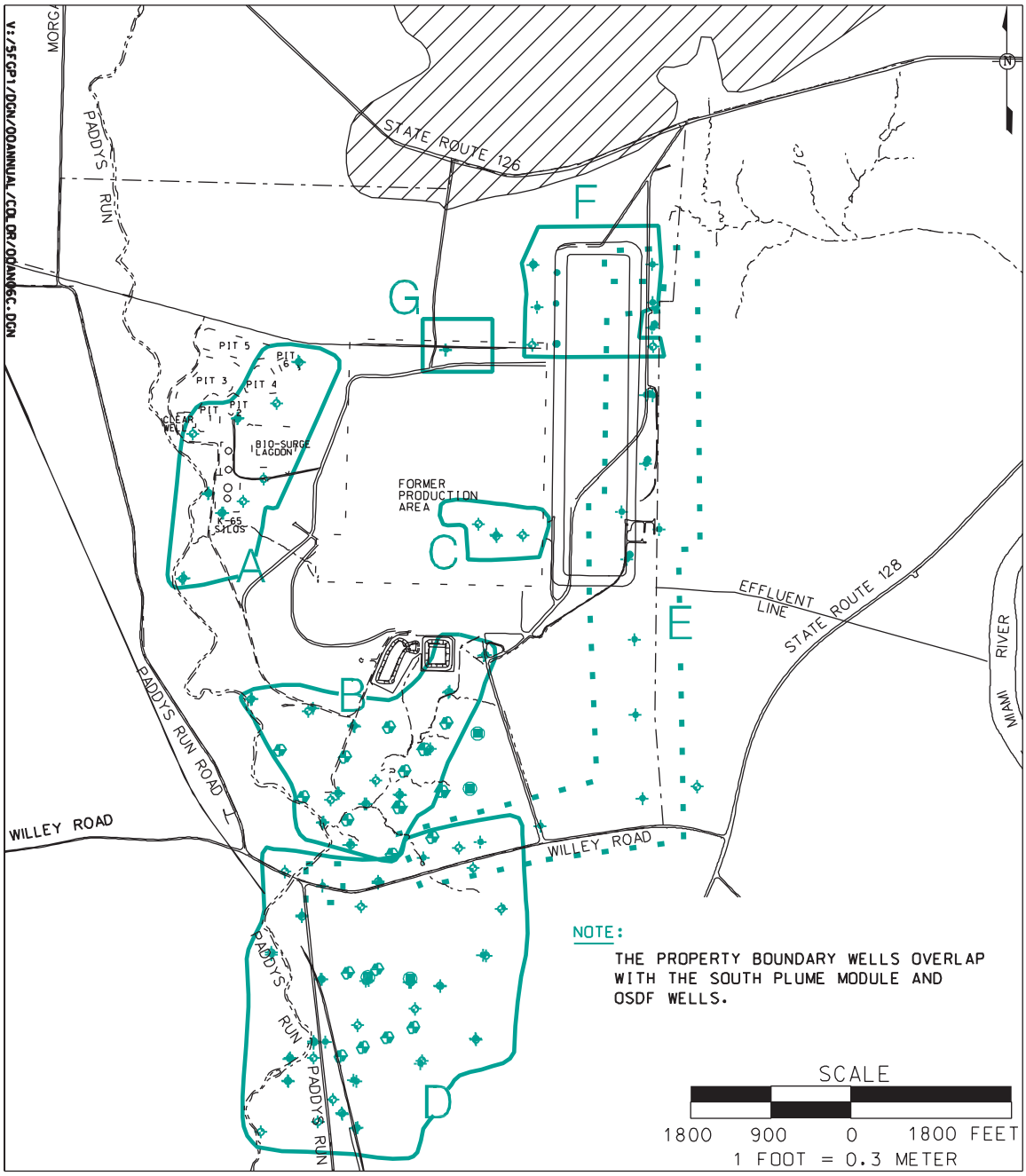


Figure 3-5. IEMP Water Quality Monitoring Wells

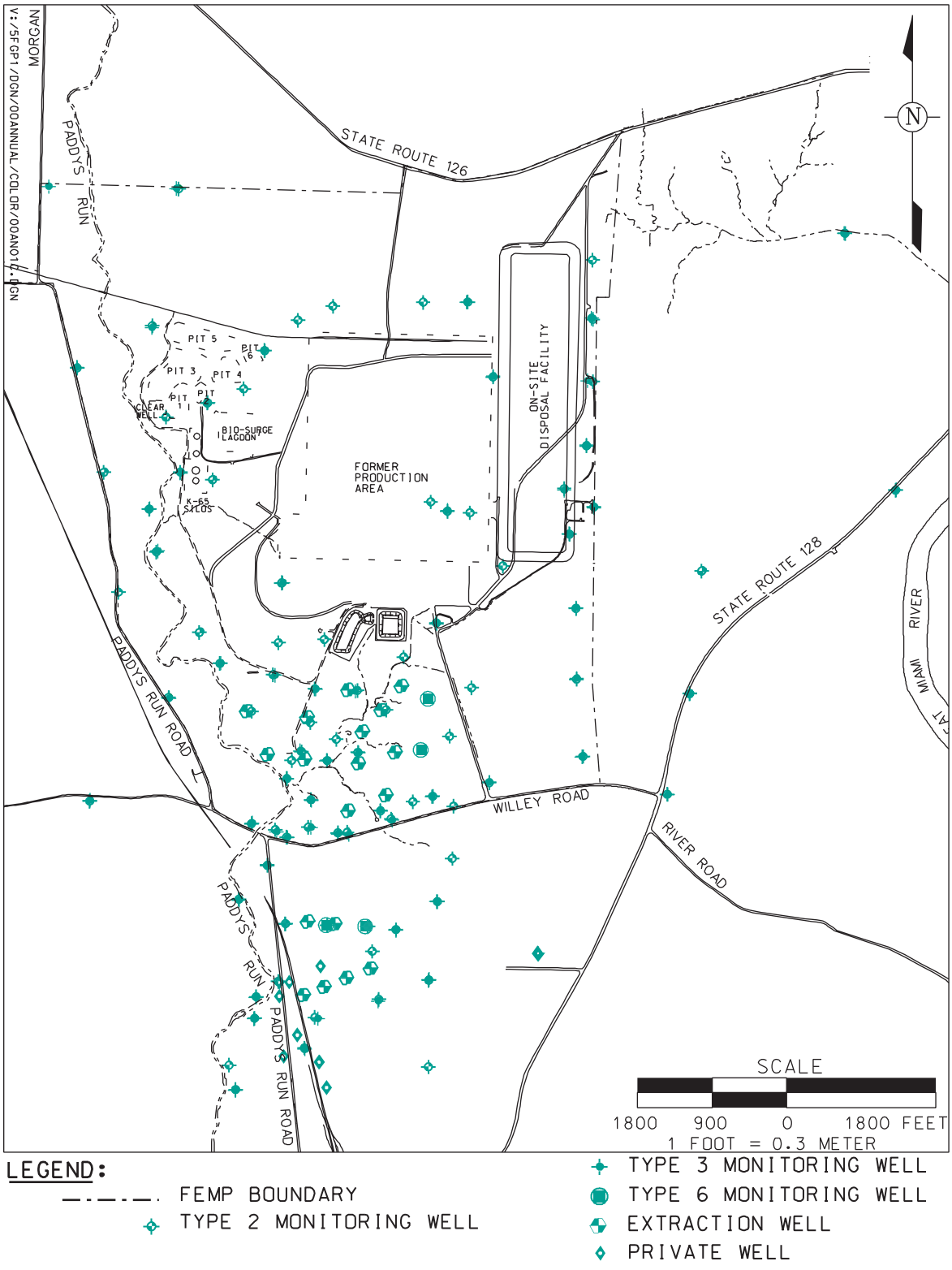


Figure 3-6. IEMP Groundwater Elevation Monitoring Wells

Operational Summary

Figure 3-2 shows the extraction and re-injection well locations associated with the current restoration modules. Table 3-1 summarizes the pounds of uranium removed and the amount of groundwater pumped by the three restoration modules active during 2000. Figure 3-7 identifies the yearly and cumulative pounds of uranium removed from the Great Miami Aquifer from 1993 through 2000. Since 1993:

- 7,516 million gallons (28,448 million liters) of water have been pumped from the Great Miami Aquifer.
- 859 million gallons (3,251 million liters) of treated water have been re-injected into the Great Miami Aquifer.
- 2,356 net pounds (1,070 kg) of uranium have been removed from the Great Miami Aquifer.

Appendix A, Attachment 1, of this report provides detailed operational information on each extraction and re-injection well, such as pumping and re-injection rates, uranium removal indices, and total uranium concentration graphs. The following subsections provide information on the individual modules.

TABLE 3-1
2000 GROUNDWATER RESTORATION MODULE STATUS

			Target Pumping Rate		Gallons Pumped/ Re-Injected		Uranium Removed/ Re-Injected	
Module	Restoration Wells	Operational Status	Gpm	Lpm	M gal.	M Liters	lbs	kg
South Plume/ South Plume Optimization Module	3924 3925 3926 3927 32308 32309	Operating since August 1993 Operating since August 1998	1,500 500	5,700 1,900	921	3,486	226	103
South Field (Phase I) Extraction Module	31550 31560 31561 31562 31563 31564 31565 31566 31567 32276 32446 32447	Operating since July 1998	1,900	7,200	958	3,626	628	285
Re-Injection Module	22107 22108 22109 22111 22240	Operating since September 1998	1,000	3,800	299	1,132	9.58	4.35
Aquifer Restoration System Totals								
(pumped)			3,900	14,762	1,879	7,112	854	388
(re-injected)			1,000	3,785	299	1,132	10	4
(net)			2,900	10,977	1,580	5,980	845	384

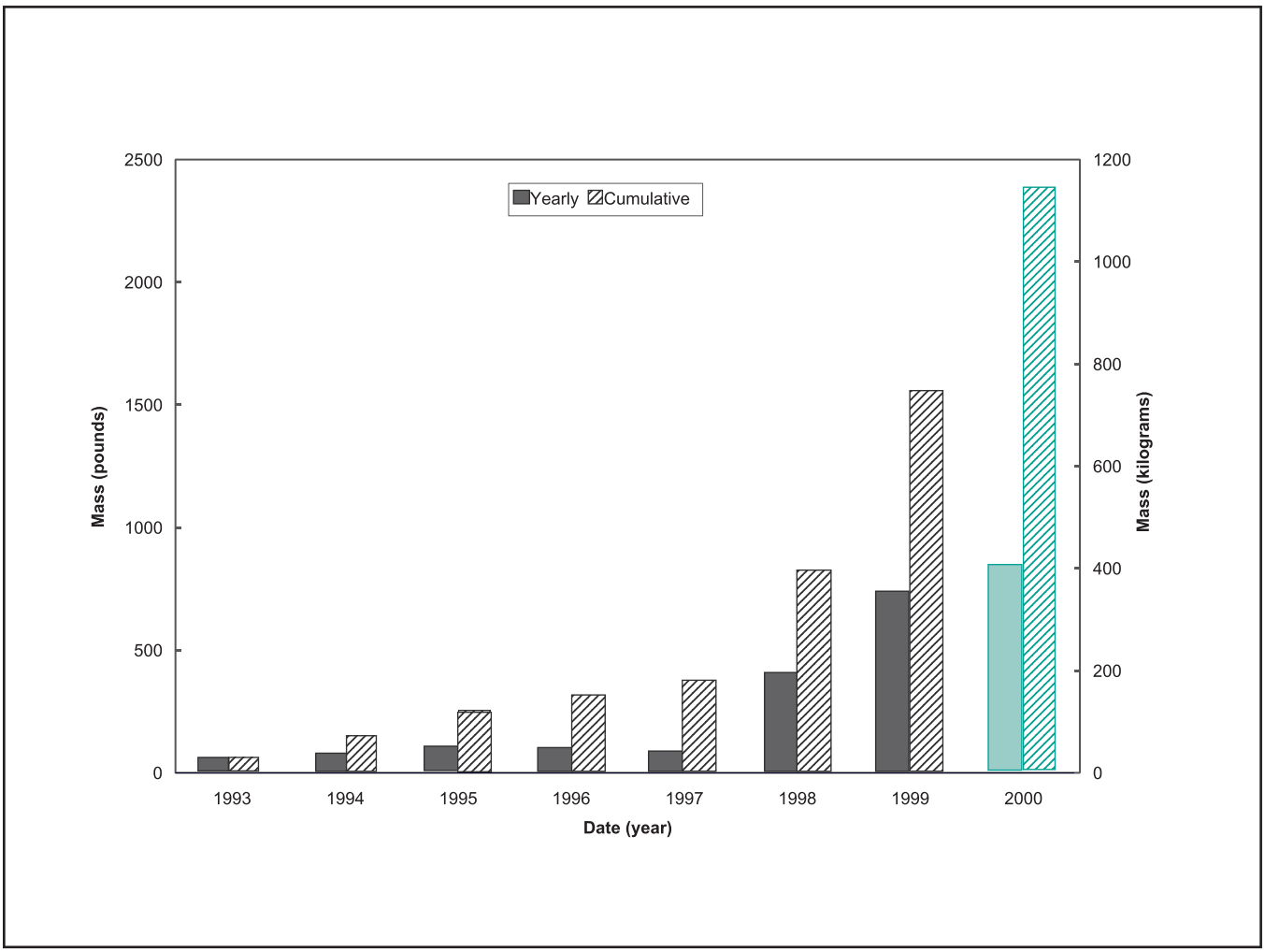


Figure 3-7. Net Pounds of Uranium Removed from the Great Miami Aquifer 1993 - 2000

South Plume/South Plume Optimization Module Operational Summary

Figure 3-8 illustrates capture zones associated with the South Plume/South Plume Optimization Module. Based on analysis of the data in 2000, the module continues to meet its primary objectives in that:

- Southward movement of the total uranium plume beyond the extraction wells has not occurred.
- Active remediation of the central portion of the off-property total uranium plume continues
- The Paddys Run Road Site plume, located south of the extraction wells, is not being adversely affected by the pumping.

The Paddys Run Road Site plume is a result of separate industrial activities along Paddys Run Road that are not associated with the FEMP.

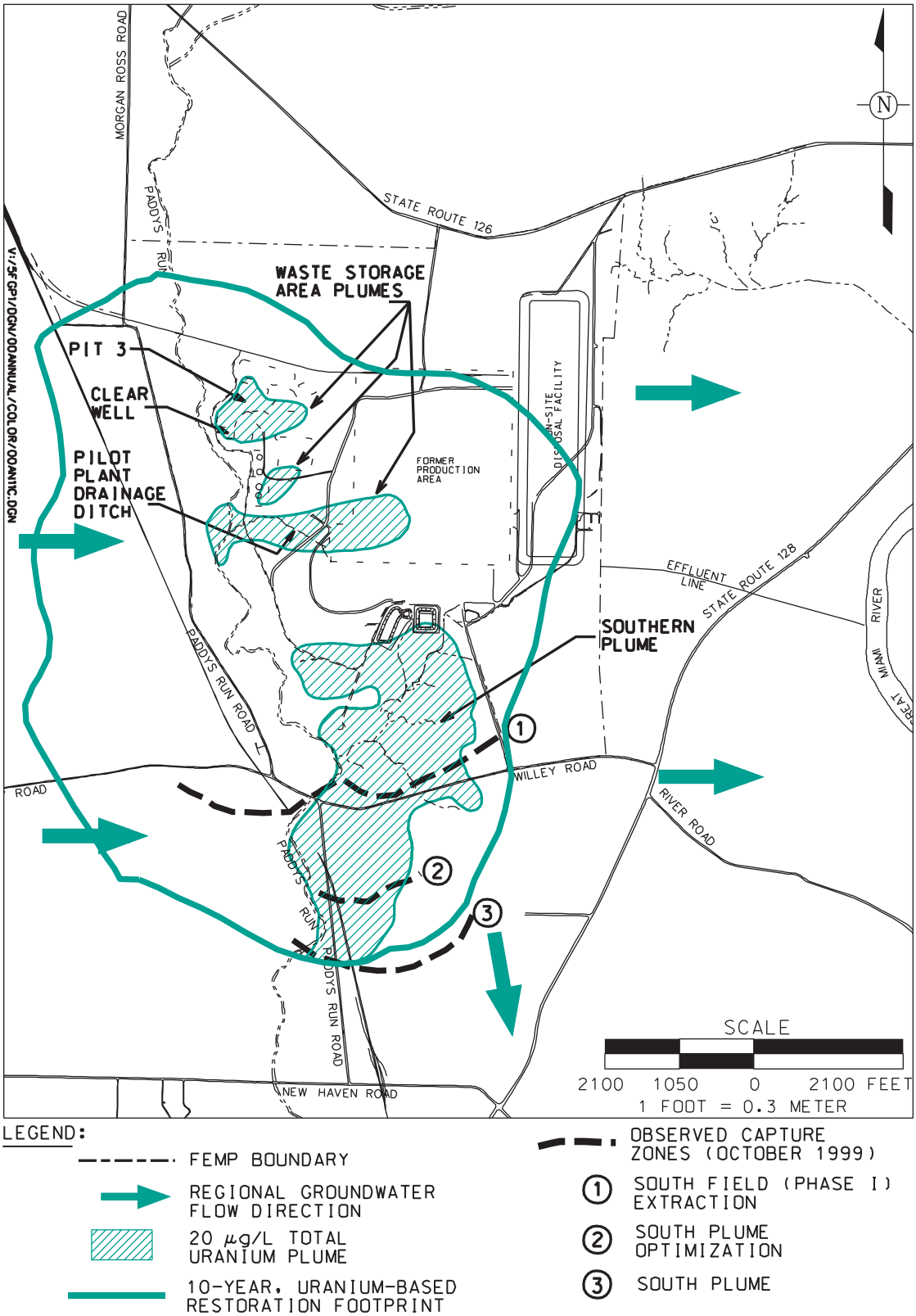


Figure 3-8. Total Uranium Plume in the Aquifer with Concentrations Greater than 20 µg/L at the End of 2000

South Field (Phase I) Extraction Module Operational Summary

The 10 extraction wells of the South Field (Phase I) Extraction Module (Extraction Wells 31550, 31560, 31561, 31562, 31563, 31564, 31565, 31566, 31567, and 32276) began operating on July 13, 1998. After evaluating the total uranium concentrations from Extraction Well 31566 in 1998 and finding the concentrations averaging much less than the 20 µg/L total uranium FRL, DOE decided to discontinue operation of this well, effective August of 1998. To compensate for the decreased total system flow with Extraction Well 31566 turned off, pumping rates were increased at Extraction Wells 31562 and 32276. Monthly sampling for total uranium was continued at Extraction Well 31566 in April of 2000 upon installation of a new sampling pump.

Figure 3-8 illustrates the capture zone associated with the South Field (Phase I) Extraction Module. As a result of groundwater remedy performance monitoring, Extraction Wells 32446 and 32447 were installed during the fourth quarter of 1999 as part of the South Field (Phase I) Extraction Module. The locations of these wells were based on refined total uranium plume interpretations in the South Field area and groundwater modeling. The wells began pumping in February 2000. Figure 3-2 identifies the location of these new extraction wells.

Re-Injection Module Operational Summary

A groundwater re-injection demonstration was conducted at the FEMP from September 2, 1998, to September 2, 1999. The Re-Injection Module consists of Re-Injection Wells 22107, 22108, 22109, 22111, and 22240. Following completion of the re-injection demonstration in September of 1999, it was decided to incorporate re-injection technology into the aquifer remedy. The Re-Injection Demonstration Test Report detailing the demonstration was issued to EPA and OEPA on May 30, 2000.

The evaluation indicated that the testing results were favorable regarding the viability of re-injection at the FEMP, that a reliable source of injection water can be maintained, and that an acceptable injection rate can be sustained without negative effects on the plume or aquifer. However, residual plugging of the re-injection wells became a concern in the last half of 2000. As of the close of 2000, the increased plugging had precipitated the need for more aggressive treatment of the re-injection wells. A revised treatment method utilizing concentrated hydrochloric acid, sodium hypochlorite, and calcium hypochlorite was approved and implemented in early December 2000. Although initial results of the aggressive treatment were encouraging, by early 2001, only one of three wells treated with the aggressive method was rehabilitated such that re-injection could resume at the design rate of 200 gallons per minute. Therefore, additional treatment methods to address this plugging are being researched.

Monitoring Results for Total Uranium

Total uranium is the primary FRL constituent because it is the most prevalent site contaminant and has impacted the largest area of the aquifer.

Figure 3-8 shows general groundwater flow directions and the interpretation of the total uranium plume in the aquifer, as updated with data collected through 2000. The shaded areas represent the interpreted size of the total uranium plume that is above the 20 µg/L groundwater FRL for total uranium. The fourth quarter 2000 observed capture zones for the South Field (Phase I) Extraction, South Plume, and South Plume Optimization Modules are also identified on Figure 3-8. These capture zones indicate that the southern plume is being captured by the existing system and that further movement of uranium to the south of the extraction wells is being prevented. Figure 3-8 also depicts that the total uranium concentrations greater than the FRL are within the 10-year, uranium-based restoration footprint which was defined in the 1997 Baseline Remedial Strategy Report.

Geoprobe®

The Geoprobe® is a hydraulically powered, direct push sampling tool that is used at the FEMP to obtain groundwater samples at specific intervals without installing a permanent monitoring well. Direct push means that the tool employs the weight of the vehicle it is mounted on and percussive force to push into the ground without drilling (or cutting) to displace soil in the tool's path. DOE uses this technique to collect data on the progress of aquifer restoration and to determine the optimal location and depth of additional monitoring and extraction wells that may be installed in the future.

The interpreted 20 µg/L total uranium plume boundary in the area of the South Field has changed in shape from 1999. The plume shape and concentration contours have been modified to better reflect the Geoprobe® sampling data in the western, on-property area of the southern plume (refer to Figure 3-8). These data were collected as part of South Field Phase II Module pre-design characterization effort. The Geoprobe® data, along with routine IEMP monitoring well data in the South Field area, continue to indicate that surface source removal, flushing of the contaminants toward the extraction wells by infiltrating surface water, and pumping the extraction wells are all contributing to reducing the total uranium concentration in the western portion of this plume, particularly beneath the former Inactive Flyash Pile. However, some monitoring wells in the eastern portion of the South Field (Phase I) Extraction Module area have steady or increasing total uranium concentrations. Options for increasing the flushing of the aquifer in the eastern portion of the South Field area are scheduled to be evaluated in 2001. These options currently include additional extraction wells, increasing the pumping rate of some existing wells (with the existing pumps) and increasing the pumping rate in some of the existing extraction wells by installing larger capacity pumps.

In the northeast portion of the South Field Module area, Geoprobe® sampling data were used to confirm the lack of a plume upgradient of Monitoring Well 3068. A camera survey, along with a pumping action at Monitoring Well 3068 confirmed the source for the uranium contamination in the well was perched water leakage into the well, rather than a uranium plume at the well. The concentration contour maps were redrawn to reflect this analysis and Appendix A, Attachment 2, provides additional detail.

As previously noted in the Selection and Design of the Groundwater Remedy section, the Plant 6 plume appears to have dissipated to concentrations below the 20 µg/L total uranium FRL and the waste storage area plume interpretation has been revised based on the pre-design characterization completed. These revised interpretations are reflected in the total uranium plume outline on Figure 3-8.

Appendix A, Attachment 2, of this report provides individual monitoring well total uranium results and quarterly total uranium plume maps for 2000. Appendix A, Attachment 3, of this report provides capture zone evaluations based on groundwater flow directions from groundwater elevation data. It includes quarterly groundwater elevation maps and graphical displays of groundwater elevation data.

Monitoring Results for Non-Uranium Constituents

Although the enhanced groundwater remedy is primarily targeting remediation of the total uranium plume, other FRL constituents (Table 2-2) contained within the total uranium plume are also being monitored.

Table 3-2 summarizes the results of monitoring for non-uranium FRL constituents, and Figure 3-9 identifies the locations of the wells that had FRL exceedances in 2000. Included in the table for each FRL constituent are the number of wells with FRL exceedances, the number of wells with FRL exceedances outside the Baseline Remedial Strategy Report 10-year, uranium-based restoration footprint, and the range of 2000 data above the FRL from wells inside or outside the Baseline Remedial Strategy Report 10-year, uranium-based restoration footprint.

TABLE 3-2
NON-URANIUM CONSTITUENTS WITH RESULTS ABOVE FINAL REMEDIATION LEVELS DURING 2000

Constituent	Number of Wells Exceeding the FRL	Number of Wells Exceeding the FRL Outside the BRSR[a] 10-Year, Uranium-Based Restoration Footprint	Groundwater FRL	Range of 2000 Data Inside the BRSR[a] 10-Year, Uranium-Based Restoration Footprint above the FRL[b]	Range of 2000 Data Outside the BRSR[a] 10-Year, Uranium-Based Restoration Footprint above the FRL[b]
General Chemistry			**(mg/L)**	**(mg/L)**	**(mg/L)**
Nitrate/Nitrite	3	0	11[c]	11.4 to 48.4	NA
Inorganics					
Arsenic	4	2	0.050	0.0609 to 0.0633	0.0595 to 0.082
Boron	2	0	0.33	0.339 to 0.857	NA
Lead	4	2	0.015	0.0191 to 0.0224	0.0157 to 0.201
Manganese	17	4[d]	0.900	0.916 to 105	0.918 to 1.3
Molybdenum	1	0	0.10	0.275	NA
Nickel	4	0	0.10	0.104 to 0.906	NA
Zinc	19	6[d]	0.021	0.0216 to 0.235	0.0252 to 0.077
Volatile Organics			**(µg/L)**	**(µg/L)**	**(µg/L)**
Trichloroethene	1	0	5.0	70.7	NA
Radionuclides			**(pCi/L)**	**(pCi/L)**	**(pCi/L)**
Technetium-99	1	0	94	181.533 to 685.581	NA

[a]Baseline Remedial Strategy Report (DOE 1997a)

[b]NA = not applicable

[c]FRL based on nitrate, from Operable Unit 5 Record of Decision, Table 9-4; however, the sampling results are for nitrate/nitrite.

[d]Additional 2001 data are needed from Monitoring Wells 22198, 2426, and 3426 before a determination of persistence can be made.

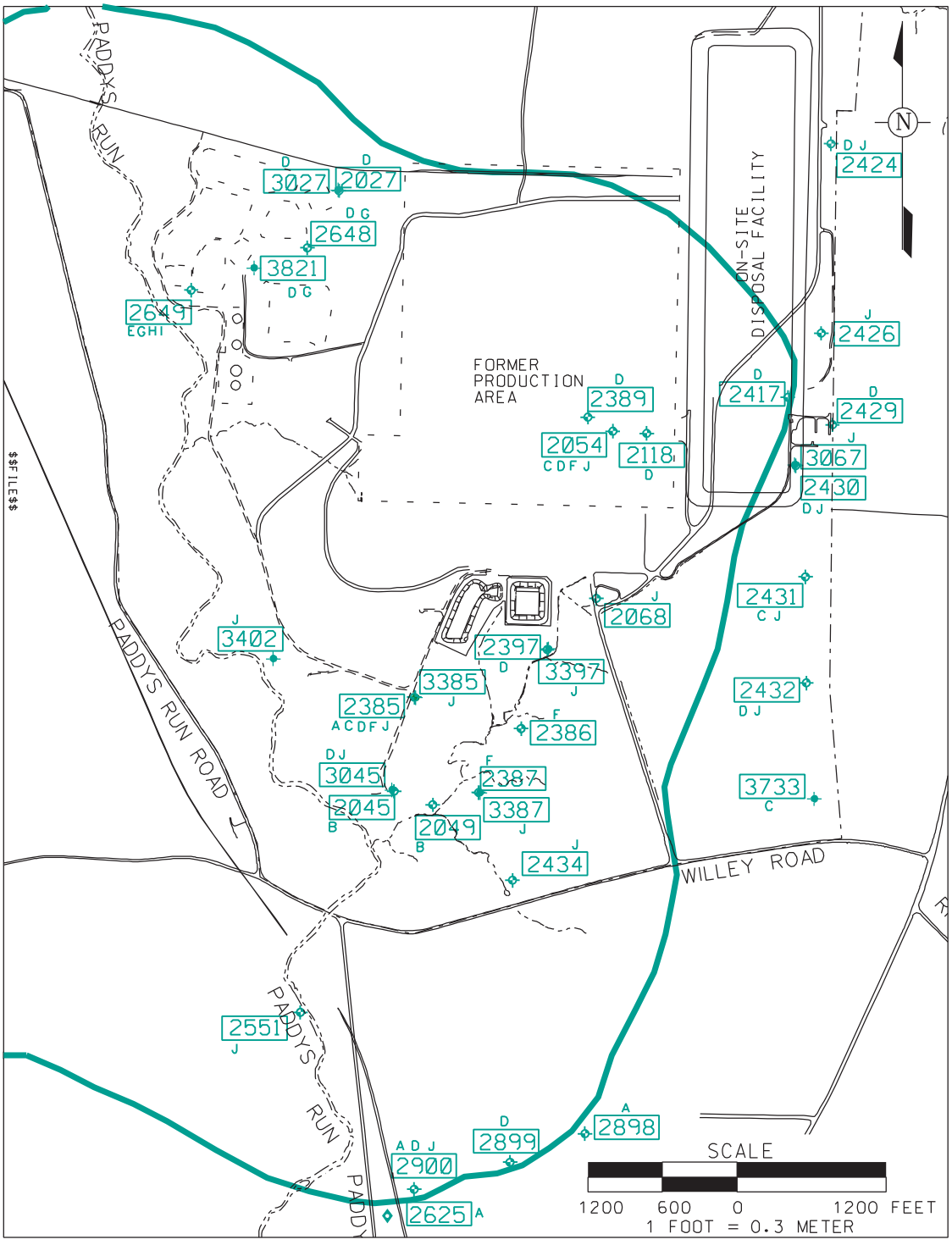


Figure 3-9. Non-Uranium Constituents with 2000 Results Above Final Remediation Levels

During 2000 non-uranium FRL exceedances were observed at 35 monitoring well locations as shown in Figure 3-9. A total of 10 non-uranium FRL constituents exceeded FRLs in 2000. All these exceedances were within the Baseline Remedial Strategy Report 10-year, uranium-based restoration footprint. They are expected to be addressed by the enhanced groundwater remedy, except exceedances for lead, manganese, and zinc at various monitoring well locations along the eastern property boundary, and arsenic in two locations just south of the footprint (refer to Figure 3-9). No plumes for the above FRL constituents at the locations outside the 10-year, uranium-based restoration footprint were identified in the extensive groundwater characterization efforts evaluated as part of the Operable Unit 5 Remedial Investigation Report.

The constituents with FRL exceedances at the well locations outside the 10-year, uranium-based restoration footprint were further evaluated to see if they were random events or if they were persistent according to criteria discussed in Appendix A, Attachment 4, of this report. Two exceedances (manganese and zinc at Monitoring Well 2430) were classified as persistent. The cause for these exceedances is not fully understood at this time. All former exceedances that were classified as persistent have disappeared with subsequent sampling. Also, as footnoted in Table 3-2, some FRL exceedances from 2000 require additional data to be collected in 2001 before a determination of persistence can be made.

Appendix A, Attachment 4, of this report provides detailed information of non-uranium FRL exceedances and the persistence of these exceedances.

Other Monitoring Commitments

Three other groundwater monitoring activities are included in the IEMP:

- Private Well Monitoring
- Property Boundary Monitoring
- KC-2 Warehouse Well Monitoring.

As stated earlier, the groundwater data from these activities, along with the data from all other IEMP groundwater monitoring activities, are collectively evaluated for total uranium, and where necessary, non-uranium constituents of concern. The discussion below provides additional details on the three compliance monitoring activities.

The three private wells (Monitoring Wells 2060 [12], 13, and 14) located along Willey Road are monitored under the IEMP to assist in the evaluation of the total uranium plume migration (refer to Appendix A, Attachment 2, Figure A.2-1 for well locations). One of these private wells is where off-property groundwater contamination was initially detected in 1981. Other private wells ceased to be monitored in 1997 because a DOE-sponsored public water supply became available to FEMP neighbors who have been affected by off-property groundwater contamination. The availability of the public water supply resulted in the plugging and abandonment of many private wells in the affected off-property areas where groundwater is being remediated. Data from the three private wells sampled under the IEMP were incorporated into the total uranium plume map shown in Figure 3-8.

Property Boundary Monitoring is comprised of 33 monitoring wells located downgradient of the FEMP, along the eastern and southern portions of the property boundary. These wells are monitored quarterly for 27 of the most mobile FRL constituents in order to determine if contaminant excursions at the property boundary are occurring during the remediation process. During 2000, the frequency of monitoring the property boundary Type 4 wells was decreased to once every five years due to lack of contamination in the aquifer at the depth these wells monitor. Data from the property boundary wells were integrated with other IEMP data for 2000 and were incorporated into the total uranium plume map shown in Figure 3-8. Non-uranium data from these wells were included above in the section on monitoring results for non-uranium constituents. Director's Findings and Orders were issued by OEPA on September 7, 2000. These orders specify that the site's groundwater monitoring activities will be implemented in accordance with the IEMP. The revised language allows modification of the groundwater monitoring program as necessary, via the IEMP revision process (subject to OEPA approval), without issuance of a new order. As determined by OEPA, the IEMP will remain in effect throughout the duration of remedial actions.

The KC-2 Warehouse well (Figure 3-5) monitoring was also to be included as part of the IEMP until such time that it could be plugged. Monitoring of this well (Well 67) was conducted on an annual basis as a result of the presence of what appeared to be contaminated sediment at the bottom of the well. As reported in the 1999 Integrated Site Environmental Report, the KC-2 Warehouse well has been removed from the IEMP sampling program. The KC-2 Warehouse well was sampled in March of 2000 and plugged and abandoned in April 2000. The March 2000 sampling results were generally lower than the historical averages. Although cyanide and sodium concentrations exceeded the historical average, there is no groundwater FRL for either constituent. The monitoring results for this well and additional detail in the sampling events are presented in Appendix A, Attachment 5, of this report.

On-Site Disposal Facility Monitoring

Groundwater monitoring for the cells of the on-site disposal facility is conducted in the glacial till (perched water) and in the Great Miami Aquifer. Groundwater monitoring in support of the on-site disposal facility continued in 2000. This monitoring program is designed to accomplish the following:

- Establish a baseline of groundwater conditions in both the perched groundwater and the Great Miami Aquifer beneath each cell of the on-site disposal facility. The baseline data will be used to evaluate future changes in perched groundwater and Great Miami Aquifer groundwater quality to help determine if the changes are due to on-site disposal facility operations.

- Continue routine groundwater sampling following waste placement and cell capping as part of the comprehensive leak detection monitoring program for the on-site disposal facility. This information will be used to help verify the ongoing performance and integrity of the on-site disposal facility.

Table 3-3 summarizes the groundwater monitoring information associated with the on-site disposal facility. Table 3-3 also summarizes leachate collection system and leak detection system monitoring information. Sampling of the leachate collection system and the leak detection system is generally initiated after waste placement, while groundwater sampling is initiated before waste is placed in a particular cell. Table 3-3 provides information for Cells 1, 2, and 3, along with sample information and range of total uranium concentrations. During 2000, design was completed on an enhanced permanent leachate transmission system, which is scheduled to replace the existing system in 2001. Construction of the new system began in May 2000.

TABLE 3-3
ON-SITE DISPOSAL FACILITY GROUNDWATER, LEACHATE, AND LEAK DETECTION SYSTEM MONITORING SUMMARY

Cell (Waste Placement Start Date)	Monitoring Location	Monitoring Zone	Date Sampling Started	Total Number of Samples	Range of Total Uranium Concentrations[a] (µg/L)
Cell 1	22201	Great Miami Aquifer	March 31, 1997	27	ND – 6.384
(December 1997)	22198	Great Miami Aquifer	March 31, 1997	40	0.557 – 8.365
	12338	Glacial Till	October 30, 1997	32	ND – 19
	12338C	Leachate Collection System	February 17, 1998	12	ND – 119
	12338D	Leak Detection System	February 18, 1998	11	1.5 - 20.17
Cell 2	22200	Great Miami Aquifer	June 30, 1997	22	ND - 1.11
(November 1998)	22199	Great Miami Aquifer	June 25, 1997	22	0.259 -12.1
	12339	Glacial Till	June 29, 1998	31	ND - 3.607
	12339C	Leachate Collection System	November 23, 1998	9	4.51 – 39.299
	12339D	Leak Detection System	December 14, 1998	9	9.334 - 71[b]
Cell 3	22203	Great Miami Aquifer	August 24, 1998	20	ND – 2.522
(November 1999)	22204	Great Miami Aquifer	August 24, 1998	20	ND – 5.924
	12340	Glacial Till	July 28, 1998	24	ND – 9.14
	12340C	Leachate Collection System	October 13, 1999	6	9.27 – 37.854
	12340D	Leak Detection System	NS[c]		

[a]ND = not detectable

[b]Data not considered reliable due to malfunction in the leachate pipeline and the resultant mixing of individual flows.

[c]NS = not sampled due to lack of water yield

At the end of 2000, baseline groundwater sampling of perched water and the Great Miami Aquifer concluded for Cells 1, 2, and 3. These data will be used to establish the initial groundwater conditions against which future sample results will be compared as part of the leak detection data evaluation process. A technical memorandum to document the baseline conditions for Cells 1, 2, and 3 is scheduled to be prepared in 2001. Starting in January 2001, the first three cells were sampled to determine post-baseline groundwater conditions. Figure 3-10 identifies the on-site disposal facility footprint and monitoring well locations.

Placement of contaminated soil and debris in Cell 1 concluded at the end of December 2000 (Cell 1 was 100 percent full). Soil and debris placement continued in Cells 2 and 3 during 2000. As of the end of December 2000, Cell 2 was approximately 51 percent full and Cell 3 was approximately 24 percent full. Based on 2000 leak detection monitoring data associated with the on-site disposal facility, the liner systems for Cells 1, 2, and 3 are performing within the specifications outlined in the approved cell design.

In all the samples collected from the horizontal till wells and Great Miami Aquifer wells, none of the constituents analyzed exceeded the groundwater FRLs. For additional information on the groundwater, leak detection and leachate sampling results for the on-site disposal facility, refer to Appendix A, Attachment 6, of this report.

Guide to Aquifer Restoration and Wastewater Project Documents

Numerous studies and reports have been issued by the FEMP during the CERCLA process to document the progress of the aquifer restoration. Table 3-4 is a reference for the reader to consult when seeking additional information about any phase of the site CERCLA process related to groundwater which has been completed to date. The dates during which the major accomplishments under the CERCLA process were performed are shown on the left. The middle column identifies the major CERCLA process, which was in progress at the time. The last column indicates the documents where significant findings, results, and recommendations can be located. These documents are available for public viewing in the FEMP Public Environmental Information Center, which is located a half mile south of the FEMP on Oakridge Drive in the Delta Building.

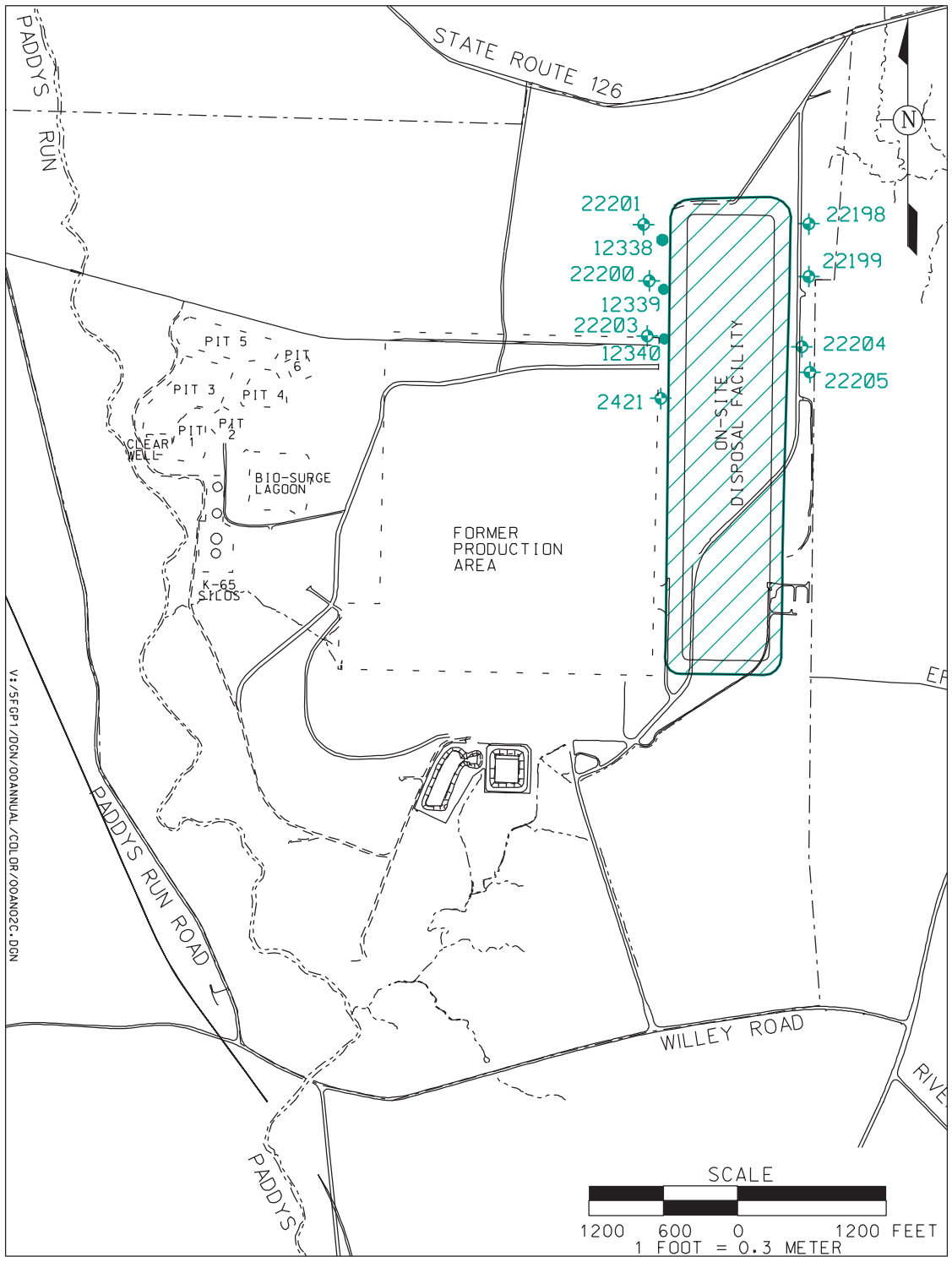


Figure 3-10. On-Site Disposal Facility Footprint and Monitoring Well Locations

TABLE 3-4

CHRONOLOGICAL SUMMARY OF KEY AQUIFER RESTORATION ACTIVITIES

Date	Activity	Documentation
1988 - 1995	Determine the Scope of the Problem and Select a Solution	
	Determine the nature and extent of groundwater contamination and investigate the risk posed to human health and/or the environment	**Remedial Investigation Report for Operable Unit 5** (1995)
	Evaluate various remediation technologies; consider efficiency, land use scenarios, and cost	**Feasibility Study Report for Operable Unit 5** (1995)
	Establish remediation goals for site contaminants in environmental media; commit to a selected cleanup remedy	**Record of Decision for Remedial Actions at Operable Unit 5** (1996)
1996 - 1997	Design and Construct a System to Clean Up the Aquifer	
	Define how and when needed construction drawings, specifications, plans, and procurement documents will be prepared	**Remedial Design Work Plan for Remedial Actions at Operable Unit 5** (1996)
	Develop a strategy and schedule for completing restoration of the aquifer	**Remedial Action Work Plan for Aquifer Restoration at Operable Unit 5** (1997)
	Design the aquifer restoration system (e.g., number of wells, pumping rates, well locations, etc.)	**Baseline Remedial Strategy Report, Remedial Design for Aquifer Restoration (Task 1)** (1997)
	Develop a plan to monitor progress of the clean up	Chapter 3 of the **Integrated Environmental Monitoring Plan (IEMP)** (1997)
	Develop operational strategy for the aquifer system	**Operations and Maintenance Master Plan for the Aquifer Restoration and Wastewater Treatment Project** (1997)
1993	South Plume Module begins operating as a removal action.	**South Plume Removal Action Design Monitoring Evaluation Program Plan** (1993)
1997	IEMP Monitoring Begins	**Design Monitoring Evaluation Program Plan System Evaluation Report** (various dates through September 1997)
		Integrated Environmental Monitoring Plan (IEMP); Integrated Environmental Monitoring Quarterly Reports
1998	South Field (Phase I) and South Plume Optimization Modules become operational	**Start-Up Monitoring Plan for the South Field Extraction and South Plume Optimization Modules** (1998)
	Re-Injection Demonstration begins	**Re-Injection Demonstration Test Plan** (1997)
1999	Re-Injection Demonstration ends	**Monthly Re-Injection Report** (September 1999) and **Integrated Environmental Monitoring Status Report for Third Quarter 1999** (December 1999)
	Revised the operational strategy for the project	**Operations and Maintenance Master Plan** (December 1999)
	Began a pre-design characterization of uranium plumes in the waste storage area and Plant 6 area	**Integrated Environmental Monitoring Status Report for Fourth Quarter 1999** (March 2000)
2000	Completed a Conceptual Design for plumes in the waste storage and Plant 6 areas	**Conceptual Design for Remediation of the Great Miami Aquifer in the Waste Storage and Plant 6 Areas** (May 2000)
	Issued Re-Injection Demonstration Test Report and added re-injection to the aquifer remedy	**Re-Injection Demonstration Test Report for the Aquifer Restoration and Wastewater Project** (May 2000)

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